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(54) Title: A LIGHT SYSTEM

(57) Abstract: A modifying structure lens (1) is formed over a LED light source (2) so as to act to focus the light into the appropriate configuration (ray direction) and simultaneously extract heat from the upper and side surface of the LED chip (2). The LED light source (2) is mounted to a rear heat sink body (4). The lens (1) comprises a primary region (5) immediately adjacent the LED source (2) (and within which the LED source (2) is embedded). The primary region (5) includes a diamond compound particulate material distributed throughout a flexible gel matrix, as will be described in detail hereafter. An overlaying layer (6) of a light transparent material is not impregnated with the diamond compound material.

A Light System

The present invention relates to a light system.

WO-A-01/04194 describes a thermally conductive material which may be used to improve the performance of a variety of products, including optical glasses.

An improved light system has now been devised.

According to the present invention, there is provided a light system comprising:

a) a light source;

b) a modifying structure contiguous with the light source and via which light from the light source is directed, the modifying structure comprising a matrix material and a particulate material distributed through the matrix material, wherein the particulate material is transparent to wavelengths of light and of high thermal conductivity.

The modifying structure is preferably capable of acting as a lens arranged functionally contiguous with a light source (such as a LED light source). The inventive combination of light source and contiguous modifying structure acting as a lens provides significant advantages over prior art arrangements as will be described in detail hereinafter.

It is preferred that the particulate material is also of high electrical resistivity. Beneficially the particulate material is a diamond material (or a material approximating a diamond material in light transparency/transmissivity

and/or thermal conductivity, and/or electrical resistivity).

The modifying structure is beneficially transparent to visible wavelengths of light. Transparent should be interpreted broadly as meaning capable of permitting desired light wavelengths or wavelength bands to pass.

It is preferred that the matrix material is transparent to desired wavelengths of light. The matrix material may have a Refractive Index (RI) matching or approximating the RI of the particulate material.

Beneficially the light source is provided with a heat sink arrangement, the modifying structure preferably being in thermally transmissive contact with the heat sink arrangement. The modifying structure of the present invention provides for good light transparency whilst, because of its good thermal conductivity, enables heat to be rapidly and efficiently dissipated from the light source. For light sources such as LED's this is important to in order to maintain technical performance, improve the life of the diode, and also control the light wavelength emitted to be consistent and substantially uniform, as required. Where a heat sink arrangement is provided, the relevant modifying structure effectively and efficiently dissipates heat from the light source to the heat sink arrangement.

The Refractive Index of the modifying structure preferably varies with distance away from the light source. Beneficially the Refractive Index of the modifying structure varies between a relatively high Refractive Index zone proximate the light source to a zone of relatively lower Refractive Index remote from the light source.

Most beneficially the zone of relatively higher Refractive Index is substantially in the range 2 - 3, the Refractive Index of the lower Refractive Index zone substantially being in the range 1 - 2.

Where LED light source is used in accordance with the invention, the LED crystal has typical Refractive Index of 3.2. The diamond compound particulate material distributed in the matrix of the modifying structure will have a Refractive Index of approximately 2.4 and the Refractive Index at the modifying structure/air interface is approximately 1.0.

Beneficially the Refractive Index of the structure is graded between the light source and the interface between the modifying structure and the air (or other medium). The grading may be continuous or stepped depending upon the performance required of the system.

The Refractive Index of the structure may be varied by variation in the loading density of the particulate material (typically diamond compound) in the matrix material, or alternatively the Refractive Index of the modifying structure may be varied by a variation in the Refractive Index of the matrix material. As a further alternative the modifying structure may include a layer of material (not loaded with dispersed particulate material) which may have a different Refractive Index to the particulate loaded matrix material region. The overlayer of material may also have variation in Refractive Index throughout its width, which may be stepped or continuously graded.

As mentioned previously, the modifying structure preferably acts as a lens to direct the light to follow a

predetermined modified path. The use of the modifying structure having the relevant particulate material distributed through the matrix layer ensures that the transmissibility characteristics are not compromised by the presence of the heat conducting particulate material.

Beneficially the matrix material of the modifying structure is flexible or elastically deformable/conformable to accommodate thermal expansion of the light source (and any differential expansion between components such as, for example, the attached heat sink arrangement). To this end it is preferred that the light source is at least partially embedded in the modifying structure. Typically the matrix material of the modifying structure comprises a gel material or the like.

The invention will now be further described in a specific embodiment, by way of example only, and with reference to the accompanying drawing which is a schematic representation of a light system in accordance with the invention.

Referring to the drawing, a modifying structure lens 1 is formed over a LED light source 2 so as to act to focus the light into the appropriate configuration (ray direction) and simultaneously extract heat from the upper and side surface of the LED chip 2.

The LED light source 2 is mounted to a rear heat sink body 4. The lens 1 comprises a primary region 5 immediately adjacent the LED source 2 (and within which the LED source 2 is embedded). The primary region 5 includes a diamond compound particulate material distributed throughout a flexible gel matrix, as will be described in detail hereafter. An overlaying layer 6 of a light transparent

material is not impregnated with the diamond compound material.

The LED may be used under continuous wave (CW) condition, in which case the heat is removed from the lens walls by conduction or convection. Alternatively, the LED may be used in a pulse operation mode, in which case the lens 1 acts as a transient heat reservoir during the on period with the heat flowing back through the LED chip and to the main heat sink body 4 during the pulse off period.

The matrix material used is typically a gel material impregnated with diamond powder to provide high thermal conductivity and a high electrical resistivity. In the immediate vicinity of the LED crystal, the gel containing the diamond powder has a Refractive Index that substantially matches (as closely as practicable) that of diamond thereby minimising light scattering. The proportion of diamond in the region immediately adjacent the LED crystal is as high as possible to provide the maximum thermal conductivity consistent with the layer being sufficiently pliable to allow for differential thermal expansion. A covering layer with lower Refractive Index (1.5/1.6) is provided with the aim of providing a gradation (in steps or continuously) from the LED crystal itself (RI 3.2) down to RI 1 at the air interface. Diamond has a Refractive Index of approximately 2.4.

The light system in accordance with the invention provides significant technical advantages over prior art arrangements. Because the modifying structure lens embedding the LED crystal acts as a heat reservoir, during pulsed operation temperature cycling of the diode is

minimised which improves the life of the apparatus by reducing stress cycling of the diode.

Efficiently cooled light source operation (particularly for LEDs) ensures that the efficiency of the light source is maximised and also ensures consistent wavelength output.

The modifying structure has been described primarily in the form of a lens. It should however be readily appreciated by those skilled in the art that other arrangements of modifying structure could be utilised without departing in scope or spirit of the invention. For example, the modifying structure would be in the form of a fibre or waveguide structural wall, the light from the light source being coupled directly into the fibre or waveguide.

The light system of the present invention is believed to have applications in numerous fields in which versatility and efficiency of light output is desired. Applications include medical and healthcare, industrial consumer and domestic and telecommunications.

CLAIMS:

1. A light system comprising:

   a) a light source;

   b) a modifying structure contiguous with the light source and via which light from the light source is directed, the modifying structure comprising a matrix material and a particulate material distributed through the matrix material, where in the particulate material is transparent to wavelengths of light and of high thermal conductivity.

2. A light system according to claim 1, wherein the particulate material is of high electrical resistivity.

3. A light system according to claim 1 or claim 2, wherein the particulate material is a diamond material (or a material approximating a diamond material in light transparency/transmissibility and/or thermal conductivity, and/or electrical resistivity).

4. A light system according to any preceding claim, wherein the light source is provided with a heat sink arrangement, the modifying structure being in thermally transmissive contact with the heat sink arrangement.

5. A light system according to any preceding claim, wherein the refractive index of the modifying structure varies with distance away from the light source.

6. A light system according to claim 5, wherein the Refractive Index of the modifying structure varies from a zone of relatively high Refractive Index proximate the light source to a zone of relatively lower Refractive Index remote from the light source.

7. A light system according to claim 6, wherein the zone of relatively higher Refractive Index is substantially in the range Refractive Index 2 to 3.

8. A light system according to claim 6 or claim 7, wherein the zone of relatively lower Refractive Index is substantially in the range Refractive Index 1 to 2.

9. A light system according to any of claims 5 to 8, wherein the Refractive Index of the structure is varied by a variation in the loading density of the particulate material in the matrix material.

10. A light system according to any of claims 5 to 9, wherein the Refractive Index of the structure is varied by a variation in the Refractive Index of the matrix material.

11. A light system according to any of claims 5 to 10, wherein the structure includes a layer of material not including the dispersed particulate material.

12. A light system according to claim 11, wherein the layer of material not including the dispersed particulate material overlays matrix/distributed particulate material region, the overlaying layer being of Refractive Index less than the Refractive

Index of the matrix/distributed particulate material region.

13. A light system according to any preceding claim, wherein the modifying structure acts as a lens to direct the light to follow a predetermined modified path.

14. A light system according to any preceding claim, wherein the light source comprises a solid state device.

15. A light system according to any preceding claim, wherein the light source comprises a light emitting diode (LED).

16. A light system according to any preceding claim, wherein the light source is at least partially embedded in the modifying structure.

17. A light system according to any preceding claim, wherein the matrix material of the modifying structure is elastically deformable/conformable to accommodate thermal expansion of the light source.

18. A light system according to any preceding claim, wherein the matrix material of the modifying structure comprises a gel material.

19. A light system substantially as herein described with reference to the accompany drawings.

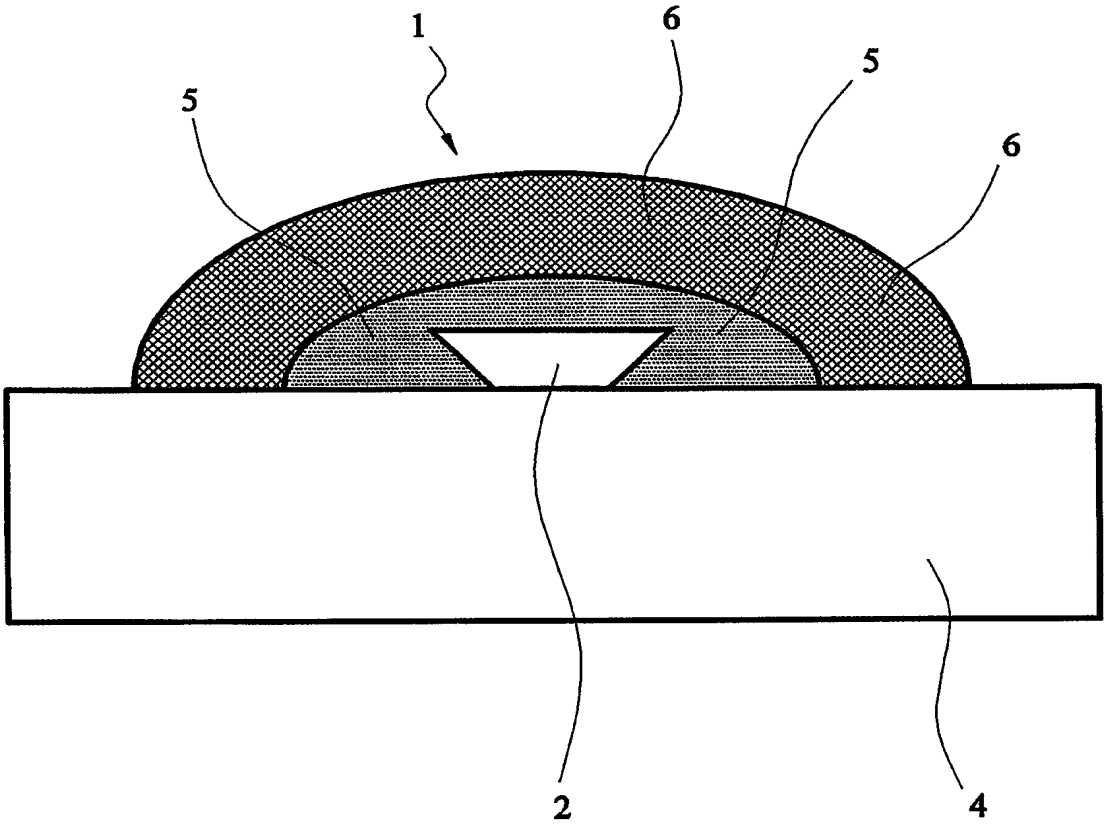

FIG. 1

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(74) Agent: **WHITING, Gary**; Abel & Imray, 20 Red Lion Street, London WC1R 4PQ (GB).

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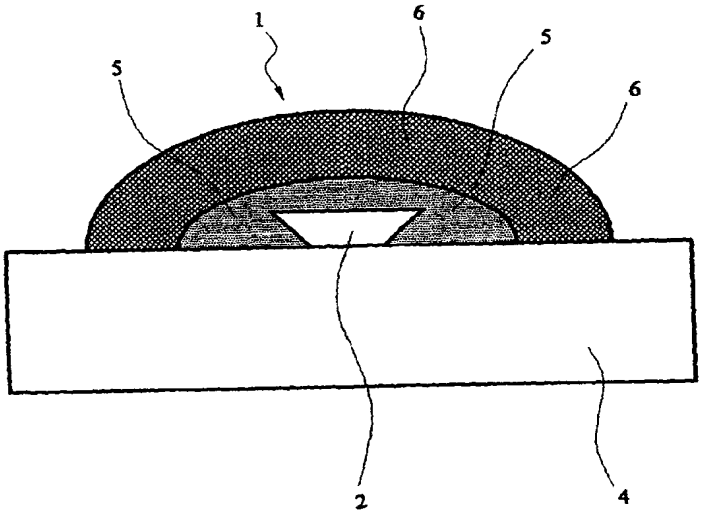

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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